

Cost of Generation Workshop: Natural Gas Technologies

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Gas-Fired Plants Costs Survey

- Previous Survey Completed in 2006 for 2007 IEPR
- Types of Plants Surveyed
 - CEC Jurisdictional
 - Simple Cycle
 - Combined Cycle (not Cogeneration)
 - Information Requested
 - Capital Costs (new plants since 2006 survey)
 - Operating Costs (plants ≥ 1 calendar year operation)

Survey Sample Pool

- Total Projects – 47 (~16,900 MW)
- Total Project Owners - 29
- Total Simple Cycle (SC) Projects – 22 (~2,900 MW)
- Total Combined Cycle (CC) Projects – 25 (~14,000 MW)
- Total Merchant Projects – 30 (14 CC, 16 SC)
- Total IOU Projects – 4 (all CC)
- Total Muni Projects – 13 (7 CC, 6 SC)
- Operating Cost Requests SC/CC – 19 / 24
- Capital Cost Requests SC/CC – 8 / 6

Capital Cost Requests

- Parameters Requested
 - Total Cost
 - Gas Turbine/Combustor Make/Model/Cost
 - Steam Turbine Make/Model/Cost (where applicable)
 - Inlet Air Treatment Type/Cost
 - Cooling Equipment Type/Cost
 - Water Treatment Cost/ZLD (Y/N)
 - Site Footprint/Land Cost
 - Total Construction Costs
 - Site Preparation Costs
 - Linear Connection Costs (Gas/Transmission/Water/Sewer)
 - Licensing/Permitting Costs
 - Air Pollution Control and Offsets Costs

Capital Cost Survey Form

Power Plant Project (XX-AFC-1XX As-Built Information Request

Confidential
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#	As-Built Capital Cost Information Request Parameter		
1	Gas Turbine Make/Models	Gas Turbine 1 Make/Model <u>GEA</u>	
2	Combustor Make/Model	Turbine 1 Combustor Make/Model _____	
3	Steam Turbine/Generator Make/Model	Steam Turbine/Generator 1 Make/Model _____	
4	Total Capital Cost of Facility	\$ MM _____ (\$ MM = Millions of Dollars) Total capital cost value basis for the costs presented above and below: 1) Instant or overnight costs <input type="checkbox"/> or Installed of final costs <input type="checkbox"/> 2) Costs are provided <input type="checkbox"/> with sales & use tax or <input type="checkbox"/> without sales & use tax included Year basis for capital costs provided above and below - 20__	<input type="checkbox"/>
	Capital Cost Details		
5	Gas Turbine/Generator Cost (installed cost each)	\$ MM _____ ;If not installed cost please list basis _____	<input type="checkbox"/>
6	Steam Turbine/Generator Cost (installed cost each)	\$ MM _____ ;If not installed cost please list basis _____	<input type="checkbox"/>
7	Inlet Air Treatment (not filtering - installed cost)	Inlet Air Treatment (Y/N?) <u>Y</u> Type <u>Evaporative Inlet Air Coolers</u> Cost \$ MM _____ If not installed cost please list basis _____	<input type="checkbox"/>
8	Cooling Equipment Cost (installed cost)	\$ MM _____ ;If not installed cost please list basis _____	<input type="checkbox"/>
9	Water Treatment Facilities (installed cost)	\$ MM _____ ZLD System (Y/N?) <u>N</u> ;If not installed cost please list basis _____	<input type="checkbox"/>
10	Site Footprint and Land Cost	Acres --- _____ \$ MM _____	<input type="checkbox"/>
11	Total Construction Costs (Labor/Equipment/etc.)	\$ MM _____	<input type="checkbox"/>
12	Cost of Site Preparation	Site Grading/Earthmoving/Compaction \$ MM _____ Soil Remediation \$ MM _____	<input type="checkbox"/>
13	Cost of Linear Connection Construction	Natural Gas \$ MM _____ Transmission \$ MM _____ Water \$ MM _____ Sewer \$ MM _____	<input type="checkbox"/>
14	Cost of Licensing/Permitting Project	\$ MM _____ (not including emissions offset costs requested below)	<input type="checkbox"/>
15	Air Pollution Control Costs	SCR \$ MM _____ Oxidation Catalyst \$ MM _____	<input type="checkbox"/>
16	Cost of Emission Reduction Credits (ERCs) or other Offsets	NOx \$ MM _____ PM10 \$ MM _____ VOC \$ MM _____ SOx \$ MM _____ CO \$ MM _____	<input type="checkbox"/>
17	Contact Person for Follow-up Questions	Name _____ Phone Number _____	

Operating Cost Requests

- Parameters Requested
 - Annual Cost (years 2006 – 2011 as applicable)
 - Operating Hours/Start & Stop Hours/# Starts
 - Duct Burner Fuel Use (as applicable)
 - Annualized Gas Price
 - Water Consumption/Cost
 - Staffing Personnel/Cost
 - Ongoing Costs (consumables, equipment, etc.)
 - Maintenance Costs
 - Fixed versus Variable Cost Definition

Operating Cost Survey Form

Power Plant (XX-AFC-XX) As-Operating Information Request			Confidential <input checked="" type="checkbox"/>
#	Operating Cost Information Request Parameter		
1	Total Annual Operating Costs (Cost should be inclusive of fuel and all other operating costs)	2006 - \$ MM _____ 2007 - \$ MM _____ 2008 - \$ MM _____ 2009 - \$ MM _____ 2010 - \$ MM _____ 2011 - \$ MM _____ Total operating cost value basis: 1) Costs are provided <input type="checkbox"/> with sales and use tax or <input type="checkbox"/> without sales and use tax included	<input type="checkbox"/>
2	Operating hours and Startups/Shutdowns Hours (average considering number of turbines at site)	2006 – Operating Hours _____ Startup/shutdown hours _____ No. of Startups _____ 2007 – Operating Hours _____ Startup/shutdown hours _____ No. of Startups _____ 2008 – Operating Hours _____ Startup/shutdown hours _____ No. of Startups _____ 2009 – Operating Hours _____ Startup/shutdown hours _____ No. of Startups _____ 2010 – Operating Hours _____ Startup/shutdown hours _____ No. of Startups _____ 2011 – Operating Hours _____ Startup/shutdown hours _____ No. of Startups _____	
3	Natural Gas – Sources of Fuel.	Utility Supplier PG&E <input type="checkbox"/> SoCalGas <input type="checkbox"/> SDG&E <input type="checkbox"/> Other secondary sources (describe) _____	
4	Duct Burner Natural Gas Usage (MMCuft)	Duct Burner Fuel Use 2006 _____ 2007 _____ 2008 _____ 2009 _____ 2010 _____ 2011 _____ Duct Burner Hours of Operation 2006 _____ 2007 _____ 2008 _____ 2009 _____ 2010 _____ 2011 _____	
5	Natural Gas Average Annual Price (\$/MMBtu)	Utility Gas - 2006 _____ 2007 _____ 2008 _____ 2009 _____ 2010 _____ 2011 _____ Other source - 2006 _____ 2007 _____ 2008 _____ 2009 _____ 2010 _____ 2011 _____	<input type="checkbox"/>
6	Water Supply Source/Cost/Consumption (2011)	Average Cost \$ _____/acre-ft, Consumption _____ acre-ft	<input type="checkbox"/>
7	Staffing (average annual cost – 2011 dollars) (please provide staffing in full time equivalents)	Managers _____ #, Operators _____ #, Mechanics _____ #, Laborers _____ #, Support Staff _____ #, Other _____ # Total Payroll _____ \$/yr	<input type="checkbox"/>
8	Ongoing Operating Costs (average annual cost – 2011 dollars)	Consumables Costs (Chemicals, etc) _____ \$/yr, Equipment acquisition and leasing costs _____ \$/yr, Regulatory Filings, etc. _____ \$/yr, Ongoing Emissions Offsets Costs _____ Other Direct Costs _____ \$/yr	<input type="checkbox"/>
9	Estimate of Actual Annual Maintenance Costs (2011 dollars)	Normal Annualized Maintenance Costs \$ _____ (include major overhauls) Major Overhaul Frequency _____ yrs, last year of occurrence 20____, cost of last major overhaul \$ MM _____	<input type="checkbox"/>
10	Fixed versus Variable O&M Costs Definition	For non-fuel costs please list the items considered as fixed cost versus variable O&M cost (please attached separate sheet if needed) Fixed O&M Costs _____ Variable O&M Costs _____	<input type="checkbox"/>
11	Contact Person for Follow-up Questions	Name _____ Phone Number _____	

Survey Response Rate

- Total Projects – 85%
 - Total Project Owners – 81%
 - Total Merchant Projects – 90%
 - Total IOU Projects – 100%
 - Total Muni Projects – 69%
 - Total Simple Cycle (SC) Projects – 91%
 - Total Combined Cycle (CC) Projects – 80%
 - Total Capital Cost (SC/CC) – 75% / 83%
 - Total Operating Cost (SC/CC) – 89% / 79%
- 2007 COG Response Rate – 100%

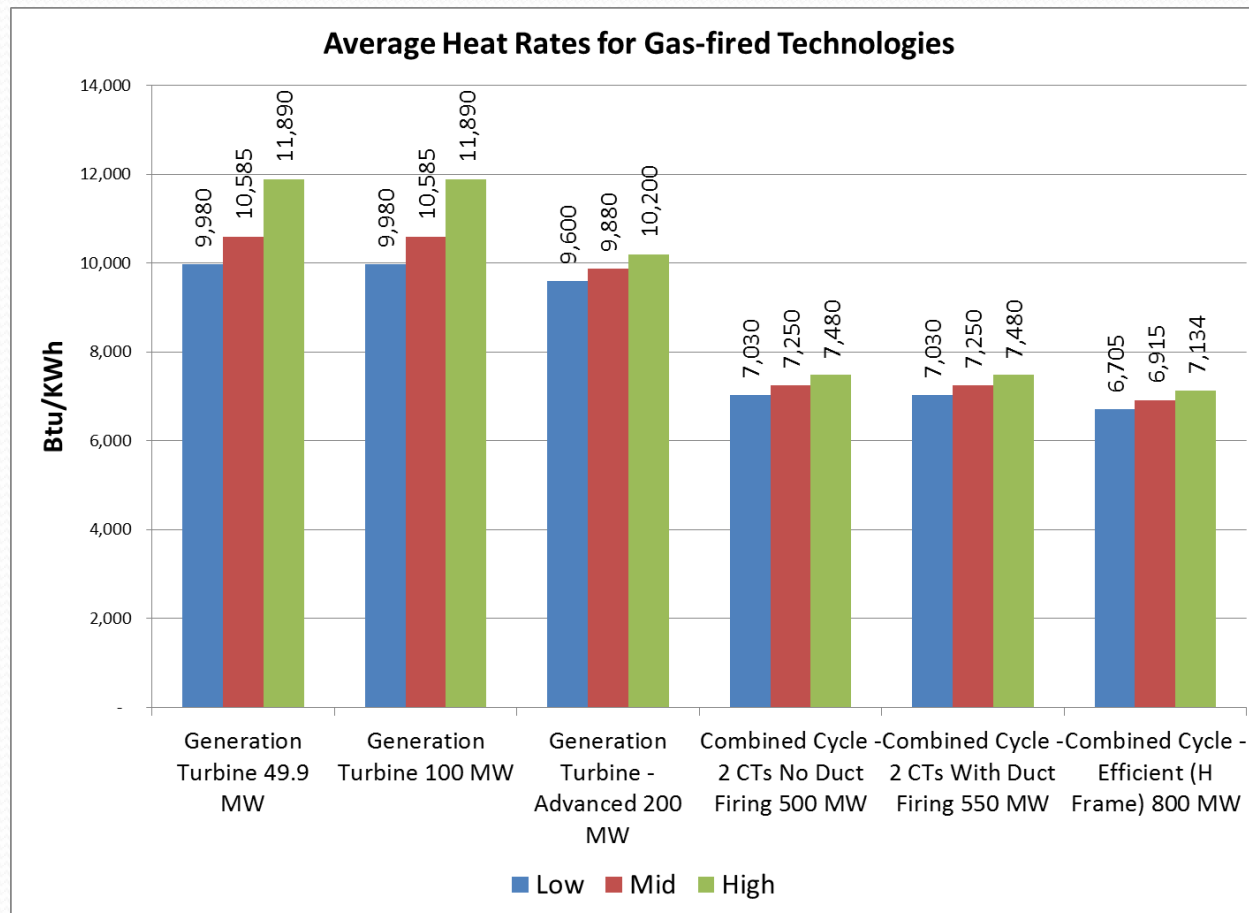
Raw Data Analysis

- Data completion adequate for COG purposes
- Total cost data appears to have no major flaws
- Certain minor data, such as duct firing fuel use, was found to have significant issues.
- Overall – data adequate for COG model use

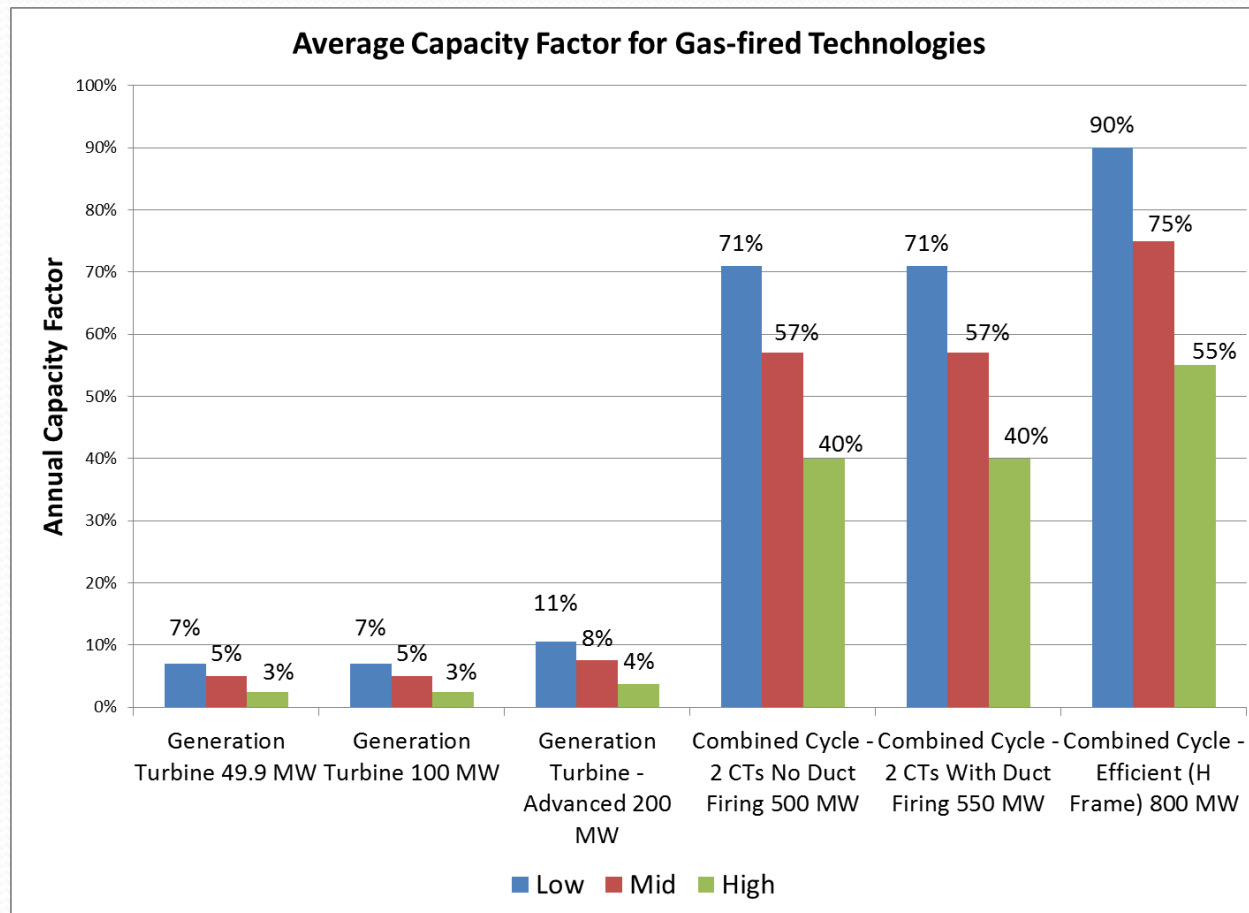
Gas-fired Plant Costs: QFER

- 2002-2011 QFER data used to derive weighted average heat rate & capacity factor estimates
- Differs from *Thermal Efficiency of Gas-Fired Generation* for two reasons
 - COG estimate drops the (partial) first year of operations
 - COG estimate uses planned rather than actual capacity
 - Planned capacity is what is used for planning purposes

Gas-fired Plant Costs: Heat Rates



Gas-fired Plant Costs: Capacity Factors



Summary of Gas Plant Factors

Survey Averages

Technology - Plant Costs Start Year = 2013 (2013 Dollars)	Gross Capacity (MW)	Instant Costs (\$/kW)	Fixed O&M (\$/kW-Yr)	Variable O&M (\$/MWh)		
Generation Turbine 49.9 MW	49.9	1,609	28.39	0.00		
Generation Turbine 100 MW	100	1,569	27.44	0.00		
Generation Turbine - Advanced 200 MW	200	1,151	25.24	0.00		
Combined Cycle - 2 CTs No Duct Firing 500 MW	500	1,257	34.56	0.61		
Combined Cycle - 2 CTs With Duct Firing 550 MW	550	1,264	34.56	0.61		
Technology Input Parameters	Gross Capacity (MW)	Capacity Factor	Heat Rate (Btu/kWh)	Degradation (%/Year)		C02 Emissions (Lbs/MWh)
				Capacity	Heat Rate	
Generation Turbine 49.9 MW	50	7.50%	10,585	0.05%	0.05%	1239.3
Generation Turbine 100 MW	100	7.50%	10,585	0.05%	0.05%	1239.3
Generation Turbine - Advanced 200 MW	200	11.25%	9,880	0.05%	0.05%	1156.8
Combined Cycle - 2 CTs No Duct Firing 500 MW	500	57.00%	7,250	0.24%	0.24%	848.8
Combined Cycle - 2 CTs With Duct Firing 550 MW	550	57.00%	7,250	0.24%	0.24%	848.8

Summary of Gas Plant Factors

High Cost Case

Technology - Plant Costs Start Year = 2013 (2013 Dollars)	Gross Capacity (MW)	Instant Costs (\$/kW)	Fixed O&M (\$/kW-Yr)	Variable O&M (\$/MWh)		
Generation Turbine 49.9 MW	49.9	2,255	75.16	0.00		
Generation Turbine 100 MW	100	2,144	73.55	0.00		
Generation Turbine - Advanced 200 MW	200	1,690	69.90	0.00		
Combined Cycle - 2 CTs No Duct Firing 500 MW	500	1,441	82.42	1.89		
Combined Cycle - 2 CTs With Duct Firing 550 MW	550	1,454	82.42	1.89		
Technology Input Parameters	Gross Capacity (MW)	Capacity Factor	Heat Rate (Btu/kWh)	Degradation (%/Year)		CO2 Emissions (Lbs/MWh)
				Capacity	Heat Rate	
Generation Turbine 49.9 MW	50	4.00%	11,890	0.05%	0.20%	1392.1
Generation Turbine 100 MW	100	4.00%	11,890	0.05%	0.20%	1392.1
Generation Turbine - Advanced 200 MW	200	6.00%	10,200	0.05%	0.20%	1194.2
Combined Cycle - 2 CTs No Duct Firing 500 MW	500	40.00%	7,480	0.24%	0.20%	875.8
Combined Cycle - 2 CTs With Duct Firing 550 MW	550	40.00%	7,480	0.24%	0.20%	875.8

Summary of Gas Plant Factors

Low Cost Case

Technology - Plant Costs Start Year = 2013 (2013 Dollars)	Gross Capacity (MW)	Instant Costs (\$/kW)	Fixed O&M (\$/kW-Yr)	Variable O&M (\$/MWh)		
Generation Turbine 49.9 MW	49.9	1,141	9.98	0.00		
Generation Turbine 100 MW	100	1,132	9.66	0.00		
Generation Turbine - Advanced 200 MW	200	728	8.93	0.00		
Combined Cycle - 2 CTs No Duct Firing 500 MW	500	1,055	13.79	0.19		
Combined Cycle - 2 CTs With Duct Firing 550 MW	550	1,054	13.79	0.19		
Technology Input Parameters	Gross Capacity (MW)	Capacity Factor	Heat Rate (Btu/kWh)	Degradation (%/Year)		CO2 Emissions (Lbs/MWh)
				Capacity	Heat Rate	
Generation Turbine 49.9 MW	50	14.00%	9,980	0.05%	0.05%	1168.5
Generation Turbine 100 MW	100	14.00%	9,980	0.05%	0.05%	1168.5
Generation Turbine - Advanced 200 MW	200	21.00%	9,600	0.05%	0.05%	1124.0
Combined Cycle - 2 CTs No Duct Firing 500 MW	500	71.00%	7,030	0.24%	0.20%	823.1
Combined Cycle - 2 CTs With Duct Firing 550 MW	550	71.00%	7,030	0.24%	0.20%	823.1